Composting or Stockpiling Feedlot Manure: Nutrient Concentration and Recovery

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Summary

Manure stockpiled anaerobically or composted aerobically for 111 days was evaluated for nutrient concentration and recovery. Recovery of dry matter (DM) and organic matter (OM) was not different among storage methods. The proportion of organic nitrogen (N) was greater for composted manure while ammonium N was greater in stockpiles. Recovery of N from stockpiled manure was greater than from compost when ammonium N was measured on "fresh" samples and samples dried down to simulate field application. Anaerobic stockpiling of feedlot manure provides a greater amount of N for crops and similar amounts of DM and OM.

Introduction

Feedlot manure removed from pens in the spring and summer is often stored until crops are harvested in the fall before field application can occur. Methods of handling and storing manure after pen removal have an impact on nutrient recoveries and manure characteristics (*2008 Nebraska Beef Report*, pp. 56-58). Transportation, handling, management and labor costs, as well as land requirements, need to be considered when deciding on a manure storage method (*1997 Nebraska Beef Report*, pp. 77-79). The objective of this research was to compare anaerobic stockpiling and aerobic composting manure storage methods on nutrient concentration and recovery.

Procedure

Manure from 11 open feedlot pens was used to determine the impact of storage method on change in amount and type of N over time for manure anaerobically stockpiled or aerobically composted. In June, scraped manure was piled on the cement apron, sampled, weighed and hauled to the compost yard. Four compost windrows and three stockpiles were constructed. Individual truckloads were weighed and sampled (n = 30) to determine amount of nutrient contribution from pen to each stockpile or windrow. Initial windrows and stockpiles contained 71 $\pm$ 1 ton of manure DM. Stockpiles were conical in shape with a base diameter of 28 ft., and windrows were 90 ft. long, 4 ft. tall, and 5 ft. wide at the base.

Windrows were turned using a mechanical compost turner on days 13, 35, 61 and 89. The compost windrows were considered "finished" when the temperature measured at a depth of 48 in. did not increase 2 to 7 days after turning (day 89). The stockpiles were left undisturbed throughout the 111 days of storage, with the exception of core and temperature samples. Stockpile and compost core samples were collected on days 36, 62 and 111. Core samples (n = 4/pile) were taken at a depth of 36 in., mixed, subsampled and frozen until analysis.

Nutrient recoveries were calculated using total ash as an internal marker with the following equation: Nutrient recovery = 100 x [(% ash initial / % ash after) x (% nutrient after / % nutrient before)]. The total amount of nutrient content also was calculated in a similar manner using total ash as a marker for DM. Nutrient concentrations are reported as g/kg; to convert to percent nutrient, divide by 10. Samples were analyzed by a commercial laboratory (Ward Laboratories Inc., Kearney, Neb.) for nutrient composition. Ammonium N was measured on samples as-is and after drying for 24 hours in a 100^{o}C oven to estimate how much N may be lost when manure is spread and exposed to high temperatures. Data were analyzed using the MIXED procedure of SAS with four replications per sampling date for compost and three replications per sampling date for stockpile. Model effects included sampling day, storage method and the sampling day x storage method interaction. Sampling day was used as a repeated measure. A single degree of freedom contrast of stockpile and compost at day 111 also was evaluated.

Results

Temperature of compost measured two to seven days following turning was considered an indicator of active composting. Compost temperature was within 100^o and 150^{o}F until the final turn (day 89) when the compost was considered "finished." Percentage DM was generally greater for the compost, compared with stockpiled manure, and varied with rainfall during the 111 days of storage (Table 1). Amount of moisture in a pile often fluctuates more with composting compared with stockpiling because of moisture loss after a turn or the incorporation of water after a rain event. The overall moisture content for compost was slightly lower (28% moisture) than the recommended level of 30-60%. Recovery of DM was not different (P = 0.81) among storage methods on day 111. Concentration of P_2O_5 also was similar (P = 0.40) among storage methods at day 111 (9.0 and 8.7 g/kg DM for stockpile and compost, respectively).

Initial percent OM was low in the manure used in this study (12.8%), which reflected the amount of soil hauled out of the pens during scraping. In the spring before removal of manure, wet conditions allowed for mixing of feces and soil, causing a greater amount of soil to be removed from the pens. Percent OM tended (P = 0.06) to be greater for stockpiled manure compared with compost

Table 1. Effect of manure storage method on nutrient concentrations and recoveries.[1]

	Stockpile				Compost						
Day[2]:	0	36	62	111	0	36	62	111	SEM[3]	*P*-value[4]	Contrast[5]
DM %	67.5[bc]	70.0[b]	69.3[bc]	66.6[c]	68.7[bc]	76.4[a]	74.9[a]	69.3[bc]	1.0	0.02	
DM recovery, %	100.0	96.0	95.4	95.1	100.0	96.7	96.0	95.2	0.5	0.76	0.81
OM %	13.0	9.4	8.8	8.5	12.4	9.3	8.7	8.0	0.2	0.25	0.06
OM recovery, %	100.0	69.5	64.9	62.5	100.0	73.1	67.7	61.6	3.2	0.70	0.77
Organic C, g/kg DM	75.5	54.6	51.3	49.5	71.7	54.1	50.3	46.2	1.2	0.25	0.06
P_2O_5, g/kg DM	8.8	8.5	8.7	9.0	8.6	8.4	8.8	8.7	0.3	0.89	0.40
C:N	10.9	10.4	9.7	9.3	10.7	10.0	9.3	9.3	0.2	0.39	0.40
N:P	1.97[a]	1.66[b]	1.51[c]	1.54[c]	1.93[a]	1.54[c]	1.44[c]	1.32[d]	0.05	0.05	< 0.01

[1]Values are expressed on a 100% DM basis.
[2]Day = sampling date from pen cleaning on day 0.
[3]Pooled standard error of the mean.
[4]*F*-test statistic for storage method by time interaction.
[5]Contrast = Single degree of freedom contrast of stockpile vs. compost on day 111.
[a,b,c,d]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 2. Effect of manure storage method and laboratory analysis on nitrogen concentration and recoveries.[1]

	Stockpile				Compost						
Day[2]:	0	36	62	111	0	36	62	111	SEM[3]	*P*-value[4]	Contrast[5]
Wet laboratory analysis[6]											
Total N recovery, %	100.0	78.5	72.9	75.8	100.0	74.8	72.6	65.6	3.4	0.14	< 0.01
Total N, g/kg DM	7.6[a]	6.2[b]	5.9[bc]	5.9[bc]	7.3[a]	5.6[c]	5.5[c]	5.0[d]	0.2	< 0.01	< 0.01
NH_4, g/kg DM	0.9[ab]	1.5[a]	1.1[a]	1.4[a]	0.9[ab]	0.6[bc]	0.4[c]	0.3[c]	0.1	< 0.01	< 0.01
NH_4, % total N	11.8[b]	23.0[a]	19.3[a]	22.4[a]	11.8[b]	10.2[bc]	8.0[c]	6.3[c]	1.6	< 0.01	< 0.01
Organic N, g/kg DM	6.7[a]	4.7[bc]	4.5[cd]	4.5[d]	6.4[a]	4.9[b]	4.6[cd]	4.2[e]	0.1	0.03	0.08
Organic N, % total N	88.3[a]	76.4[c]	78.5[c]	74.0[d]	88.5[a]	87.3[ab]	83.1[b]	84.7[b]	1.6	< 0.01	< 0.01
Nitrate N, ppm	0[d]	33[d]	133[bc]	216[b]	0[d]	100[bcd]	500[a]	475[a]	57	< 0.01	< 0.01
Dry laboratory analysis [7]											
Total N recovery, %	100.0	75.1	69.9	70.5	100.0	71.8	70.5	65.0	3.2	0.33	0.10
Total N, g/kg DM	7.2	5.6	5.2	5.3	6.9	5.1	5.0	4.7	0.2	0.06	< 0.01
NH_4, g/kg DM	0.4[d]	0.6[bc]	0.7[ab]	0.7[a]	0.4[d]	0.5[c]	0.4[d]	0.3[e]	0.1	< 0.01	< 0.01
NH_4, % total N	5.1[d]	9.9[b]	13.3[a]	13.3[a]	5.4[d]	9.3[b]	8.5[bc]	6.6[c]	1.2	< 0.01	< 0.01

[1]Values are expressed on a 100% DM basis.
[2]Day = sampling date from pen cleaning on day 0.
[3]Pooled standard error of the mean.
[4]*F*-test statistic for storage method by time interaction.
[5]Contrast = Single degree of freedom contrast of stockpile vs. compost on day 111.
[6]Samples analyzed wet, values expressed on a 100% DM basis.
[7]Samples analyzed after drying in a 100°C oven for 24 hours to estimate ammonia losses.
[a,b,c,d,e]Within a row, means without a common superscript letter differ ($P < 0.05$).

on day 111 (8.5% and 8.0%, respectively). Organic C tended ($P = 0.09$) to be greater for stockpiled manure compared with compost on day 111 (49.5 and 46.2 g/kg DM, respectively). Recovery of OM was not different ($P = 0.77$) among storage methods on day 111 (62.5% and 61.6% for stockpiled and composted manure, respectively).

Ammonium N (% of total N) in the stockpile increased from day 0 and remained at levels higher than in the fresh manure, while the amount of ammonium N in the compost decreased throughout the storage period (Table 2; 22.4% and 6.3% for stockpiled and composted manure on day 111, respectively). The decrease in organic N (% of total N) was greater ($P < 0.01$) for the stockpiles than for composted manure (74.0% and 84.7% on day 111, respectively). Nitrate N (ppm) increased throughout the 111-day storage period for both methods and was greater ($P < 0.01$) for compost than for stockpiled manure on days 62 and 111. Concentration of total N was greater ($P < 0.01$) for stockpiled manure compared with compost on days 36 and 111 (5.9 and 5.0 g/kg DM on day 111, respectively). Similarly, total N recoveries were greater ($P < 0.01$) for stockpiled manure than for compost on day 111 (75.8% and 65.6%, respectively). It is generally assumed that ammonium N is rapidly converted to ammonia N and volatilized, suggesting a greater amount of N loss would occur after stockpiled manure is spread on fields. Results from data obtained using oven-dried samples indicate that total N recovery tended ($P = 0.10$) to be greater for stockpiled manure than for compost (70.5% and 65.0%, respectively), even though a greater amount

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of N may be lost from the ammonium N fraction during spreading.

Organic C was lost at a more rapid rate than N during the storage period, resulting in a decrease in the C:N ratio for both storage methods throughout the 111 days. The C:N ratio was similar ($P = 0.40$) for the two storage methods on day 111. Because phosphorus is not volatilized, the N:P ratio decreases for both storage methods over time. Greater N loss from composting resulted in a lower ($P = 0.05$) N:P ratio at days 36 and 111.

Proportionally, the largest loss of DM, OM and N for both storage methods occurred during the first 36 days of storage. During this time, OM and N losses may be similar for stockpiled manure and compost because oxygen trapped in the stockpile during pen scraping and construction may allow for conditions favorable for aerobic bacteria to break down nutrients. The differences on day 111 for OM and N in stockpiled and composted manure may be due, in part, to the continued addition of oxygen in the compost compared with the anaerobic environment in the stockpile.

The results of this study for N losses were similar to those found in 2008 *(2008 Nebraska Beef Report*, pp. 56-58). When compared on a crop nutrient basis, stockpiling feedlot manure has a greater value than composting. Similar DM recoveries and moisture content of the two storage methods indicate volume and weight are not substantially influenced with either method. Added costs for management, labor, land and equipment needed for composting may not be offset by a decrease in transportation cost to the field. When these factors are coupled with nutrient recoveries, anaerobic stockpiling of feedlot manure may be more economically favorable.

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